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NOVEL PHASE RETARDER GENERATES CIRCULAR POLARIZATION ON LINEAR UNDULATOR BEAMLINE

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Recently, magnetic x-ray dichroism (MXD) experiments were performed using the output of a novel soft xray retarder that converts x-rays from linear polarization to circular polarization. This work is only possible because of the development a simple yet powerful design of an inline phase retarder; approximately a quarter wave plate (based upon a multilayer used in transmission mode, by Jeff Kortright of LBL). Because of the incredibly high brightness of the U5 undulator at the Spectomicroscopy Facility, even with the optical losses incurred by the conversion, very high counting rates resulted, permitting the photoemission dichroism experiments to be performed quickly and at very high resolution (total energy resolution of 100 meV or less and angular resolution of 2 degrees or better.) Because of the finite lifetime of magnetic surfaces, and the requirement that resolution be sufficient to permit the examination of peak shapes and individual contributions within the core level multiplets, such a combination of high counting rates and high resolution is essential. The systems studied included FeNi ultrathin alloy films grown on Cu(001) and Gd(0001) grown on Y(0001). In the FeNi ultrathin films, we are investigating the nanoscale version of Invar quenching and the Gd 4f's are prototypes for a study of rare-earth magnetism. Strong dichroic signals were observed in both systems, using a "normal" emission configuration with electrons collected parallel to the surface normal. One of the goals of this work is a direct experimental comparison of magnetic x-ray circular dichroism (MXCD) and magnetic x-ray linear dichroism (MXLD). In MXLD, the chirality necessary for magnetic sensitivity comes from configuration of the experimental vectors (electron emission, photon direction, photon linear polarization, crystallographic vectors) in a "handed" or chiral manner. Alternatively, circularly-polarized radiation is intrinsically chiral and permits a wider range of experimental geometries to be used. Previous results for MXCD from SSRL, a second generation source, and using bend magnetic technology, provided tantalizing but incomplete insight into the relationship. Only with the combined high resolution and high counting rates from the ALS have we been able to make a quatitative comparison of MXCD and MXLD. A partial analysis of the results suggest that existing theories give an incomplete description of the relationship, with larger MXCD effects (relative to the corresponding MXLD effects) than predicted by theory. Studying effects such as these are essential to obtaining a complete and fundamental understanding of nanoscale systems with spin dependences, thus opening the door

to controlled design of nanoscopic magnetic structures and, ultimately, devices such as sensors and storage media. Further analysis is in progress. The development of this phase retarder technology now permits the utilization of such "quarter wave plates" on any linear undulator beamline, providing for the conversion of x-rays from linear to circular polarization, for photon energies up to 150 eV. (We still need the EPU for higher energies.) Additionally, there are plans to use this circular polarization to extend magnetic sensitivity to the microscopy measurements on Beamline 7, using the scanning photoemission microscope presently under construction. One powerful advantage of MXCD photoemission is the combination of elemental specificity with magnetic sensitivity. In MXCD spectromicroscopy, those characteristics would further be wedded with the impact of small x-ray spot size, providing a magnetic microscopy with elemental specificity and magnetic sensitivity. Finally, more sophisticated MXCD/MXLD photoelectron spectroscopy experiments are also planned, such as variants of photoelectron diffraction with magnetic sensitivity.

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